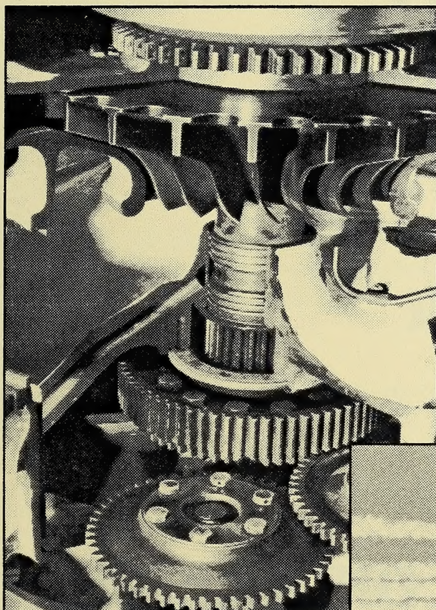
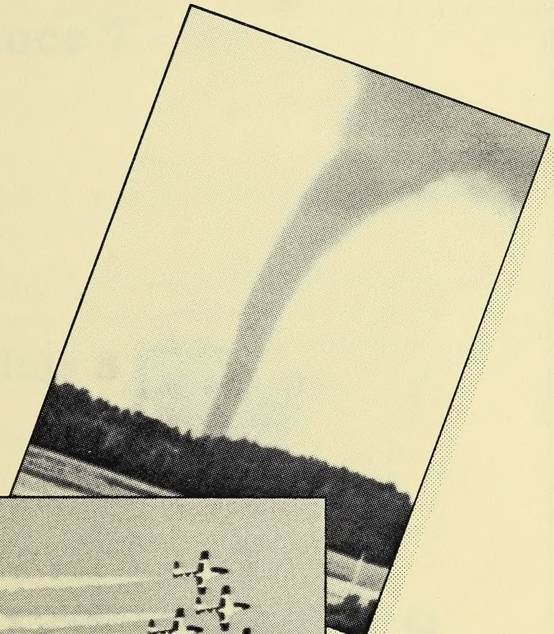
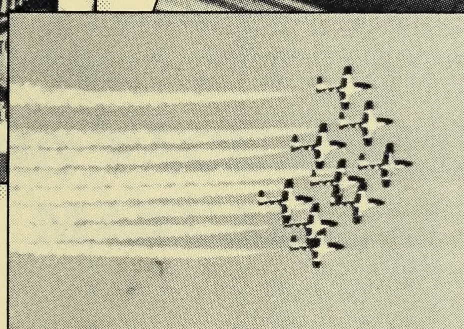
SCIENCE 7

LEARNING FACILITATOR'S MANUAL







MODULE 3:
FORCE AND MOTION

Distance Learning

Alberta
EDUCATION

Science 7

Module 3

LEARNING FACILITATOR'S MANUAL

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ACKNOWLEDGEMENTS

This module has been based on **Science Directions 7** by John Wiley & Sons/Arnold Publishing Ltd., 1989. Program consultant was Douglas A. Roberts. The author team for the complete text included Wilson C. Durward, Eric S. Grace, Gene Krupa, Mary Krupa, Alan J. Hirsch, David A.E. Spalding, Bradley J. Baker, and Sandy M. Wohl. Contributing author was Jean Bullard. Portions of **Science Directions 7** have been used throughout and have been adapted in a variety of ways.

Cover photographs courtesy of Dave Mussell, Edmonton.

Note

This Science Learning Facilitator's Manual contains answers to teacher-assessed assignments and the final test; therefore, it should be kept secure by the teacher. Students should not have access to these assignments or the final tests until they are assigned in a supervised situation. The answers should be stored securely by the teacher at all times.

Science 7
Learning Facilitator's Manual
Module 3
Force and Motion
Alberta Distance Learning Centre
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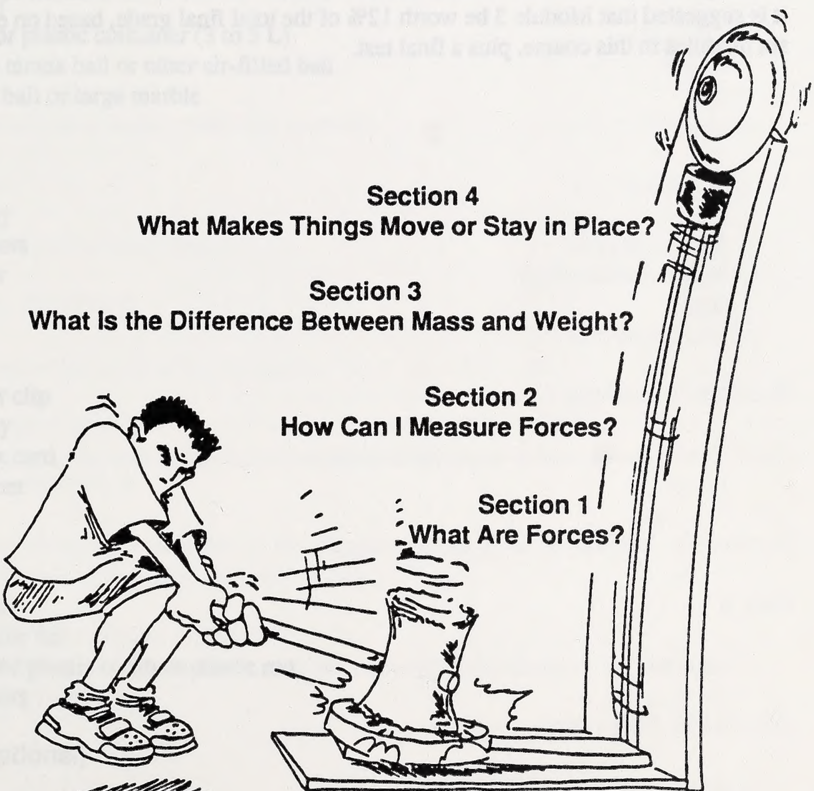
Module 3 - Force and Motion: Overview

The major emphasis of this module is on the nature of science. For the most part, the module uses an observational and experimental approach, but at the same time many of the practical applications support the other two emphases of the Science 7 program.

Module 3 provides students with the opportunity to study a variety of forces and to examine the effects of these forces on objects and materials. Students will learn how to recognize and measure forces within different systems and in different applications. A study of the causes and effects of friction and a study of motion in space are also part of Module 3.

From the study of Module 3, students will see how forces act on all things and how forces effect them every day of their lives.



Evaluation

The student's successful completion of all assignments will depend on practice obtained while doing the various activities. Many choices of activities have been provided so that students have some control over their own learning.

The following distribution of marks is suggested in determining the student's grading for this module.

Section 1 Assignment	**25 %**
Section 2 Assignment	**20 %**
Section 3 Assignment	**20 %**
Section 4 Assignment	**35 %**
TOTAL	**100 %**

Although the value of each module for the Science 7 course is the decision of the classroom teacher, it is suggested that Module 3 be worth 12% of the total final grade, based on equal weighting of the six modules in this course, plus a final test.

Materials Needed For Module 3

Comment:

For a complete overview of the materials needed for Module 3 and how the topics are developed, it may be helpful to preview the contents of Module 3. In some cases if the materials suggested are not readily available, the learning facilitator may be able to substitute suitable materials for the student, so that the activities can be completed successfully.

The materials needed for Module 3 and the activities in which they are to be used are as follows:

Section 1: Activity 2

Part A

- water
- pail or plastic container (3 to 5 L)
- table tennis ball or other air-filled ball
- steel ball or large marble

Part B

- penny
- scissors
- paper

Part C

- paper clip
- penny
- index card
- magnet

Part D

- paper
- wool or fur
- unused plastic comb or plastic rod
- scissors

Part E (Optional)

- metre stick
- rubber ball
- rigid foam ball

Part F

- piece of rug or piece of heavy cloth
- piece of wood
- two bricks or other object with rough surface

Section 1: Extra Help

Elastic Forces:

- rubber band
- ruler
- 100 g mass

Magnetic Forces:

- paper clip
- thread
- tape
- magnet

Buoyant Forces:

- several pennies
- large container (4 L)
- water
- small plastic lid

Section 2: Activity 1

Note: Students will need to select from available household materials to design and build a force meter.

Section 2: Activity 2

Part B

- force meter (spring scale) calibrated in newtons

Section 2: Extra Help

- spring scale calibrated in newtons
- paper clip
- two magnets
- 1000 g mass

Section 2: Enrichment

- large container (about 4 L)
- spring scale (force meter) calibrated in newtons
- water
- string
- stone
- three objects of your choice

Section 3: Activity 1

Note: Students should be encouraged to do Part A. However, in circumstances where it is not possible to obtain some of the following materials, students should do Part B, which does not require any materials.

Part A

- spring scale
- balance scale
- set of standard masses calibrated in grams
- apple
- eraser
- book
- three objects of your choice

Section 4: Activity 2

- index card (or piece of heavy paper)
- penny
- water glass or beaker

Section 4: Activity 4

- two bricks or other small heavy flat objects with rough surface
- spring scale calibrated in newtons
- string
- piece of wood (30 cm × 50 cm)
- piece of linoleum (30 cm × 50 cm), or other smooth surface
- cooking oil

Section 4: Activity 6

Note: Students are to do either Part A or Part B.

Part A

- sheet of stiff cardboard (10 cm × 20 cm)
- marbles (25 or more)
- wind-up or battery-powered toy car or truck

Part B

- two small (5 cm) binder rings
- a long balloon
- string
- tape
- two chairs
- spring clip

Section 4: Extra Help

- table tennis ball
- golf ball

Comments:

In place of a table tennis ball and golfball, other objects of similar size but different masses can be used. For example, a glass marble and steel ball bearing; or a regular tennis ball and a baseball will work well.

Section 4: Enrichment

Part B (Optional)

- 15 cm copper pipe or PVC tubing with the ends smoothed
- 100 g of metal washers
- fishing line or strong string
- one-hole rubber stopper
- two paper clips

Section 1: What Are Forces?

By the end of this section students should be able to

- infer that a force is being applied to an object by observing its movement
- describe the direction of a force
- identify examples of gravitational, magnetic, frictional, buoyant, and electrostatic forces
- predict the effects of forces

Section 1: Activity 1

Note: Students are to do either Part A or Part B.

Part A

Comments:

All answers for the questions in Part A should be based on the illustrated material on pages 142 and 143 of *Science Directions 7.*

1. Describe two examples of pushing forces. (What is being pushed? What is doing the pushing?) The following has been done for you.
   Example: *A teeter-totter is pushed upward. The rider pushes with his or her feet.*

   Answers will vary. The following three answers are examples:

   - *A baseball bat hits a ball, driving it forward.*
   - *The water toy is being pushed ahead by the pressure of the child's hands against the water.*
   - *A skateboarder does a hand-stand. The skateboarder's hand pushes against the hill inside the track.*

2. Describe two examples of pulling forces. (What is being pulled? What is doing the pulling?)

   Example answers:

   - *The parachutist pulls down the parachute while falling.*
   - *The kite-flyer pulls on the string.*
   - *The parachutist on the ground pulls the parachute toward herself or himself.*

3. a. Describe two examples of the force of **gravity** at work.

      Example answers:

      - *The parachutist is pulled down by gravity.*
      - *The people on the trampoline come back down.*
      - *Rocks fall after sliding over a cliff.*

b. In which direction is this force acting?

The force is acting downward.

4. a. Identify and describe evidence of forces that are lifting objects against the force of gravity.

Example answers:

- *The inflatable toy dinosaur floats on the water instead of sinking.*
- *The airplane flies instead on falling to the ground.*

b. In which direction are they acting?

The force is acting upward.

5. Identify and describe evidence of a force produced by springiness or elasticity.

Example answer: The person bouncing from the trampoline does so because of the springiness of the trampoline's surface.

6. Identify and describe evidence of a force that is slowing down the motion of an object.

Example answer: The girl who has just landed on the water makes a big splash as the water slows her fall.

7. Identify and describe evidence of a force that is stopping the motion of an object.

Example answers:

- *The trees are leaning over in the wind, showing that there is a force pushing them sideways. There must therefore be a force stopping the trees from falling over.*

- *The kite-flyer is leaning back to keep the kite from flying away.*

8. Identify and describe evidence of a force that is acting in a downward direction.

Example answer: The water from the stream falls as it comes over the cliff.

Part B

Read the questions for Part A; then go outside to find answers. If you have difficulty finding evidence, look at the illustrations for Part A to get some ideas.

Answer the questions for Part A.

Answers will vary. They will be similar to ones given in Part A but will be based on what students see around them rather than what is shown in the picture.

Section 1: Activity 2

> Note: Students are to do all of Parts A, B, C, D, and F. Part E is optional.

Comments:

Students might find it helpful to refer to the photographs on pages 144 and 145 of the textbook, *Science Directions 7*, to help them complete Parts A to F.

For each of the following parts

- Read the Steps to Follow.
- Do each step and observe what happens.
- Note the direction of the force.
- Note whether the force is a push or a pull.

Part A

Observations

Type of Ball	Observations When Dropped	Observations When Released Under Water
table tennis	*The ball stays at the surface.*	*The ball rises to the surface.*
steel	*The ball sinks to the bottom.*	*The ball stays at the bottom.*

Questions to Answer

1. Was there any downward force shown in Part A?

   Describe the evidence for your answer.

   Yes, the table tennis ball dropped to the water. The steel ball dropped to the water and sank.

2. Was there a force acting upward?

   Describe the evidence for your answer.

   Yes, the table tennis ball rose to the surface of the water.

3. Was there a force acting sideways?

   Describe the evidence for your answer.

   No, there was no sideways movement.

Part B

Observations

Way of Dropping	Observations When Dropped
dropped apart	*The penny dropped faster than the paper.*
dropped together	*The penny and paper dropped at the same speed.*

Questions to Answer

4. Was there any downward force shown in Part B?

   Describe the evidence for your answer.

   Yes, the penny and paper dropped downward.

5. Was there a force acting upward?

   Describe the evidence for your answer.

   Yes, the paper did not fall as fast when it was not with the penny.

6. Was there a force acting sideways?

   Describe the evidence for your answer.

   No, none of the materials moved sideways.

Part C

Observations

Object	Observations When Magnet Moved
paper clip	*The paper clip moved in the same direction as the magnet.*
penny	*The penny did not move.*

Questions to Answer

7. Was there any downward force shown in Part C?

   Describe the evidence for your answer.

   Yes, the paper clip was pulled downward towards the magnet.
   The force of gravity may also be mentioned in student answers.

8. Was there a force acting upward?

   Describe the evidence for your answer.

   Yes, the magnet was pulled upward towards the paper clip.

9. Was there a force acting sideways?

   Describe the evidence for your answer.

   Yes, the paper clip moved sideways.

Part D

Observations

Object	Observations of Pieces of Paper
plastic unrubbed	*The paper moved only when it was pushed.*
plastic rubbed	*The pieces of paper stuck to the comb.* *(In some cases, the paper pieces may be alternately attracted and repelled.)*

Questions to Answer

10. Was there any downward force shown in Part D?

    yes or no

    Describe the evidence for your answer.

    Answers may vary. In most cases students will not infer a downward force, but the force of gravity on the materials may be mentioned.

11. Was there a force acting upward?

    Describe the evidence for your answer.

    Yes, the comb picked up pieces of paper.

12. Was there a force acting sideways?

    yes or no

    Describe the evidence for your answer.

    Answers may vary. In some cases the pieces of paper may move sideways, depending on the position of the comb relative to the paper.

Part E (Optional)

Observations

Type of Ball	Height of Bounce
rubber ball	*Answers will vary. Some balls will bounce almost to the height from which they were dropped, while others will not bounce as high. If allowed to bounce, each bounce will be less than the preceding one.*
rigid foam ball	*The rigid foam ball does not bounce, or at best only a very low bounce occurs.*

Questions to Answer

13. Was there any downward force shown in Part E?

    Describe the evidence for your answer.

    Yes, both balls dropped downward to the floor.

14. Was there a force acting upwards?

    Describe the evidence for your answer.

    Yes, the rubber ball bounced back up after hitting the floor.

15. Was there a force acting sideways?

    Describe the evidence for your answer.

    No, there was no sideway movement.

Part F

Observations

Surface Used	Observations For One Brick	Observations For Two Bricks
pushed on rug surface	*fairly hard to move*	*requires more force to move than for one brick*
pushed on wood surface	*fairly easy to move*	*requires more force to move than for one brick*

Questions to Answer

16. Was there any downward force shown in Part F?

    yes or no

    Describe the evidence for your answer.

    Answers may vary. In most cases students will not infer a downward force as there is no downward movement, but the force of gravity on the materials may be mentioned.

17. Was there a force acting upward?

    yes or no

    Describe the evidence for your answer.

    Answers may vary. In most cases students will not infer an upward force, but the surfaces do exert a force that counters the force of gravity.

18. Was there a force acting sideways?

    Describe the evidence for your answer.

    Yes, the brick was moved sideways. To move the brick required a noticeable amount of force.

Section 1: Activity 3

For the following questions, name the forces that are affecting the motion. Choose from the following list. You may use each force more than once. You may use more than one force for each example.

- gravity
- friction
- electrostatic force
- magnetism
- buoyancy

1. Bernie has two nickels. He touched them both with a magnet. The magnet picked up one nickel but not the other. Bernie noticed that the nickel picked up by the magnet had been minted in 1979, and the nickel not picked up by the magnet had been minted in 1989.

   a. List the force or forces present in this example.

   magnetic force (or magnetism)
   gravitational force (or gravity)

   b. What evidence is there for each of these forces?

   The attraction of the nickel to the magnet is evidence of magnetic force.
   The fact that one of the nickels stayed in place is evidence of gravitational force.

2. Sarah cut two identical squares of aluminum foil. She rolled one square into a ball and folded up the edges of the other square to make a small container. She then placed them both on the surface of a container of water. The ball shape sank to the bottom; the container shape floated on the surface of the water.

   a. List the force or forces present in this example.

   gravitational force (or gravity)
   buoyant force (or buoyancy)

   b. What evidence is there for each of these forces?

   The sinking of the ball-shaped piece of foil is evidence of gravitational force.
   The floating of the container-shaped piece of foil is evidence of buoyancy.

3. Ernst placed a book on one end of a breadboard. He slanted the breadboard by lifting the end the book was sitting on. When he lifted the end of the breadboard 10 cm, nothing happened to the book. When he lifted the end of the breadboard 30 cm, the book slid to the lower end of the breadboard.

   a. List the force or forces present in this example.

      gravitational force (or gravity)
      frictional force (or friction)

   b. What evidence is there for each of these forces?

      The sliding of the book down the breadboard is evidence of gravity.
      The book staying in place is evidence of friction.

Section 1: Follow-up Activities

Extra Help

Elastic Forces

Comments:

If a 100 g standardized mass is not available, students can use the 100 g test bag containing sand or other suitable material from Module 2.

Observations

length of rubber band = ___________ cm

Answers will vary.

length of rubber band and 100 g mass = __________ cm

Answers will vary. This measurement will be greater than the previous one.

Questions to Answer

1. What force caused the rubber band to stretch?

   Gravitational force caused the rubber band to stretch.

2. What was the direction of the force?

   The direction of the force is downward.

Magnetic Forces

Diagram

- Draw a diagram in the following box to show what you did.

Diagrams will vary, but should show one end of a thread tied to a paper clip and the other end taped to a table. A magnet should also be part of the diagram. Most likely the string will be stretched to the limit with the magnet just beyond the paper clip. The magnet should not be touching the paper clip.

Questions to Answer

3. What force moved the paper clip **away** from the table?

   The paper clip was moved by magnetic force.

4. What was the direction of the force?

   The direction of the force is upward.
   In some cases, students may also move the paper clip sideways.

5. What force moved the paper clip **toward** the table?

   The paper clip was pulled downward by gravitational force.

Buoyant Forces

Observations

number of pennies that floated = __________

Answers will vary.

Questions to Answer

6. What force made the pennies and the lid float?

   A buoyant force held up the pennies and lid.

7. What was the direction of the force?

   The force acted in an upward direction.

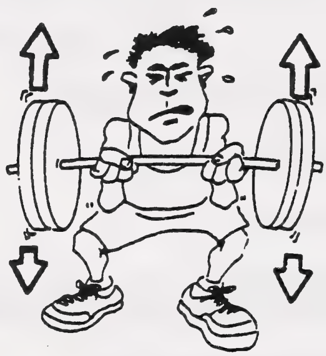
8. Why did the lid sink or tip when too many pennies were added?

The gravitational force became greater than the buoyant force.

Enrichment

1. Look at the photograph of the weightlifter shown on page 147 of the textbook. Whether he is able to lift the barbells higher or not depends on the balance between his upward force and the downward force of gravity.

   Sketch the weightlifter in the following space. Draw arrows to show that his lifting force is greater than the force of gravity pulling the barbells down toward the Earth.



Answers should include arrows that indicate a greater upward force than downward force.

2. Now look at the illustration of the man pulling the boy on the toboggan, on the bottom of page 147 of the textbook. The toboggan has started to move and is gathering speed as it is pulled.

   a. Are the forces balanced or unbalanced?

   The forces are unbalanced.

   b. How do you know?

   The toboggan is speeding up as it is pulled, or the arrows show that the forces are unbalanced.

   c. What force is represented by the arrow pointing to the left?

   The force represented is a frictional force.

3. Now it is your turn to think up an example. Think of an example of two forces acting in opposite directions. Choose from the following forces.

   - gravitational force
   - frictional force
   - electrostatic force
   - magnetic force
   - buoyant force

   Draw a sketch of the example you have chosen. Use arrows to show the direction and size of the forces. Label your sketch to show which two forces you are illustrating.

Answers will vary. Examples chosen should show two (or more) forces which are relevant to the example, and these forces should be named.

Section 1 Assignment

(25 Total Possible Marks)

Comments:

Although the value assigned to each question is the decision of the classroom teacher, suggested values are given in brackets as a guide.

1. List five different kinds of force in the chart on the response page. (5) Give one example of each force. (5)

   Other types of forces and examples may be given. The following are provided as examples.

Force	Example
• *gravitational force*	*body weight*
• *electrostatic force*	*attraction between clothes in drier*
• *buoyant force*	*:he force which keeps a boat afloat*
• *magnetic force*	*the force that holds magnetic letters on a refrigerator door*
• *frictional force*	*the force required to open a drawer*

2. Since you cannot see a force, how do you know when a force is present? (5)

   A force is evident from its effects. For example, you know that your body is subject to gravitational force, because after you jump up you always come down.

3. Turn to page 193 of *Science Directions 7* , and examine the set-up shown beneath question 8. Explain what is happening in the "Gravity Defying Paperclip" set-up. (5)

   The paper clip is attracted to a magnet which is just under the cloth.

4. Explain what is meant by the statement: *Forces seldom work alone.* (5)

   Usually for every force in a given direction, there is a restraining force in the opposite direction. For example, gravity is the restraining force for lifting a weight.

Section 2: How Can I Measure Forces?

By the end of this section students should be able to

- identify ways to detect and measure force
- describe how a force meter works
- recognize and use units of force (newtons)

Section 2: Activity 1

Getting Started

To design and build a force meter you need to think about

- its function – Your force meter will be used to measure the strength of forces required to move books and other objects found in the room.

- its structure and design – You will need to decide what different parts to use in your force meter and how you will join them together.

The following questions will help you get started. Jot down some ideas for each question.

1. For a force meter to work, a part of the meter has to be moved by the force. For a large force it should be moved quite a bit; for a small force it should be moved just a little. Some springy or elastic material might be used. What can you think of that is springy or elastic?

   Answers will vary. Answers should show evidence of critical thought regarding the appropriateness of the material used.
   Example answers: an elastic band, a springy piece of metal.

2. You may want to have a way to pull some things and push others. What could you attach to your meter that would help it push or pull?

   Answers will vary. Answers should show evidence of critical thought regarding materials and techniques to be used.
   Example answer: A hook could be attached to a rubber band which is connected with whatever is to be moved. Other parts of the force meter may include a large dowel, or a cut broom handle, inside a cardboard tube.

3. Sometimes you may need to measure forces that are fairly weak; other times you may need to measure forces that are fairly strong. Can you think of a way to make adjustments to your force meter so that it can measure both strong and weak forces?

   Answers will vary. Answers should show evidence of creativity and critical thought regarding materials and techniques to be used.
   Example answer: The number of elastics used or the size of elastics used could be changed depending on the size of force.

Comments:

Students are to design and build their own force meter by using any suitable available material they wish. They are to follow the instructions under *Steps to Follow* in the Module Booklet but may refer to pages 148 and 149 of the textbook for ideas. If after testing their force meter on several objects, students found that their force meter did not work well, the learning facilitator should encourage students to make changes to improve their design. If the student is still having difficulty, some helpful suggestions may be given by the learning facilitator. Questions 4 and 5 are to be done after the student did the tasks mentioned under *Steps to Follow*.

4. From step 2, list the three tasks from most force required to least force required.

Task a	*Task c*	*Task b*
most force		least force

5. a. Did the tasks require more force or less force than lifting the 100 g mass?

      In most cases the forces to move the book will all be greater than 100 grams.

   b. How do you know?

      This will be indicated by the amount of deflection shown on the student's force meter.

Section 2: Activity 2

> Note: Part A is optional. Students may do it if they wish.
> However, students must do Part B.

Part A: Calibrating a Force Meter (Optional)

Students may develop a calibrated force meter. Check the accuracy of the scale on their force meter. (The test bags constructed in Module 2 may be used as the 100 g, 300 g, etc. masses, if standardized mass sets are not available.) The force meter should be calibrated from 0 N to 10 N in 1 N divisions.

Part B: Using a Force Meter

Observations

<table>
<tr><th>Action</th><th>Estimated Force</th><th>Measured Force</th><th>Direction of Force</th></tr>
<tr><td>lifting a book</td><td colspan="3" rowspan="7">Comments:

Answers will vary. Depending on the size of book, it may take 5 N or 20 N to lift it. It takes about 10 N to 15 N to twist open an ordinary doorknob. Check for certain trends. For example, sliding an object will require less force than lifting an object. Also check that the arrows represent the "Direction of Force" accurately. Lifting requires an upward force, sliding requires a sideways force, turning a doorknob requires a twist to the left, opening a refrigerator door requires a pulling force.</td></tr>
<tr><td>sliding a book across a table</td></tr>
<tr><td>sliding a book across a carpet</td></tr>
<tr><td>turning on a light switch</td></tr>
<tr><td>opening a sliding door</td></tr>
<tr><td>turning a doorknob</td></tr>
<tr><td>opening a refrigerator door</td></tr>
</table>

Questions to Answer

1. List the three actions that required the most force, and then list the three actions that required the least force.

   most force

   least force

   Answers will vary. Answers should be consistent with the results shown in the student's observations chart.

2. Describe how you could use a force meter to measure each of the following:

   a. the force of gravity on an object

      Lift the object using the force meter. Observe the reading on the force meter.

   b. the force of friction on an object

      Pull the object using the force meter. Observe the reading on the force meter while you are pulling.

   c. the force of a magnet on an object

      Pull the object using the force meter on one side and holding the magnet fixed in one place.

   d. the force of buoyancy on an object

      Measure the weight of an object; then measure the apparent weight if it is suspended in water. Subtract to find the difference between the two readings. This is the buoyant force.

Section 2: Follow-up Activities

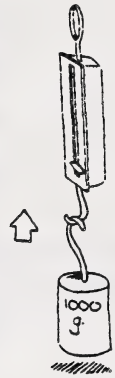
Extra Help

Comments:

If a 1000 g standardized mass is not available, students can use a substitute such as a 1 kg bag of sugar, salt, flour, etc. Remember, a 1 kg bag of a substance will likely have a mass slightly more than 1 kg because the mass of the packaging material is included.

Questions to Answer

Use the spring scale and the 1000 g mass to answer the following questions.



1. Hook the spring scale onto the 1000 g mass. Lift until the spring scale reads 8 N. Did the 1000 g mass lift off the table?

   No, the mass will not be lifted by a 8 N force.

2. How many newtons of force are required to lift the 1000 g mass?

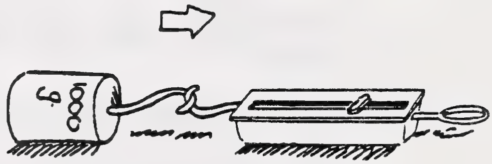
   Approximately 10 N of force are required to lift a 1000 g mass.

3. Apply 1 N of force in an attempt to drag the 1000 g mass across a table. Will the mass move?

   The mass will not likely move.

4. How many newtons of force are needed to drag the 1000 g mass across the table?

   Answers will vary, but should be significantly less than 10 N.



5. What force is the spring scale pulling against?

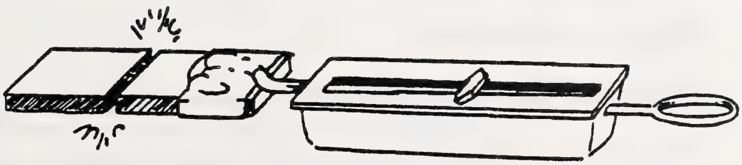
   The spring scale is pulling against frictional force.

6. Attach a paper clip to the spring scale. Touch a magnet to the other end of the paper clip. Pull the spring scale. How many newtons of force are needed to pull the paper clip away from the magnet?

   Answers will vary with the strength of the magnet.

7. Tape the spring scale to one end of a magnet. Touch the other end of the magnet to the end of a second magnet that attracts it. Pull the spring scale. How many newtons of force are needed to pull the magnets apart?

   Answers will vary. This will be a much stronger force than for question 6 (perhaps 10 to 20 times as great).



8. What force is the spring scale pulling against?

   The spring scale is pulling against magnetic force (or magnetic attraction).

Enrichment

Comments:

In this activity students are to measure the strength of a buoyant force acting on objects in water. The instructions on how to do this are given in the Module Booklet. However, they may refer to the Force of Buoyancy on page 176 of *Science Directions 7* for additional information if needed.

Observations

<table>
<tr><th>Object</th><th>Weight in Air (N)</th><th>Weight in Water (N)</th><th>Buoyant Force (N)</th></tr>
<tr><td>stone</td><td colspan="3" rowspan="4">Answers will vary depending on the objects chosen by the student. The buoyant force is calculated by subtracting the weight in water from the weight in air.

Check to see that the student has completed the chart for three objects of their choice in addition to the one object (stone) stated.</td></tr>
<tr><td></td></tr>
<tr><td></td></tr>
<tr><td></td></tr>
</table>

Questions to Answer

1. What is the main force acting on the stone before it is put in the water?

   The force acting on the stone is gravitational force.

2. In which direction is this force acting?

   This force is acting downward.

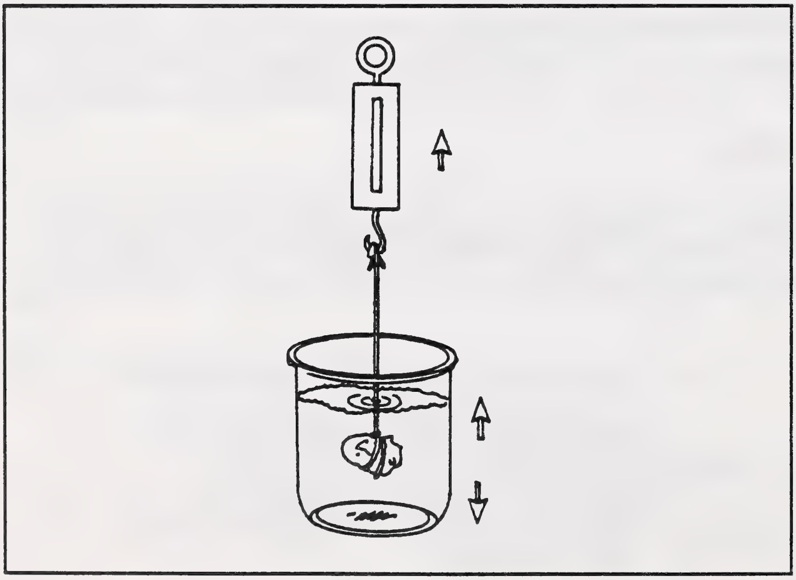
3. What forces are acting on the stone when it is immersed in water?

   The forces acting on the stone are gravitational force, buoyant force, and the upward force of the string.

4. In which direction is each of these forces acting?

   The gravitational force acts downward. The buoyant force acts upward.
   The string also pulls upward.

5. Sketch the stone immersed in water; draw arrows showing the two forces acting on it.



6. A log has a weight of 200 N. What would the buoyant force be if the log was floating in a lake?

   Give a reason for your answer.

   The buoyant force would be 200 N. The upward force and the downward force are equal.

Section 2 Assignment

(20 Total Possible Marks)

1. Write two hints that you would give to help someone build a good force meter. (4)

   Answers will vary. Two marks should be awarded on the clarity and the critical thought for each of the two hints.

   Examples:

   - *Select an elastic material for the main working part.*
   - *Calibrate the force measure to show the amount of force.*

2. How could you check to find out if a spring scale was measuring accurately? (4)

   Answers will vary. Marks should be awarded on the basis of the potential effectiveness and practicality of procedures suggested.

   Example: The spring scale could be checked by examining the readings when the scale is used to lift a mass of known weight. For example, when lifting a mass of 1 kg, the scale should read about 10 newtons.

3. Describe how you could measure the force of friction acting on a boat as it moved through water? (4)

   Answers will vary. Marks should be awarded on the basis of the potential effectiveness and practicality of procedures suggested.

   Example: Attach a force measurer to the front of the boat and pull the boat through the water at a constant speed. Read the force meter.

4. When you hang an object from a force meter, its spring or elastic band will stretch until the upward force is equal to the downward force.

   a. What is the downward force called? (2)

      The downward force is called gravitational force (or gravity).

   b. How can you tell when these two forces are balanced (equal)? (2)

      The object is still; it does not move up or down.

   c. How can you tell when they are unbalanced (unequal)? (2)

      The object goes up and down; it moves.

5. What is a newton? (2)

A newton is a unit of force.

Section 3: What is the Difference Between Mass and Weight?

By the end of this section students should be able to

- describe changes in gravitational force that result from a change of position in space
- distinguish between mass and weight
- measure the mass of an object
- recognize and use units of mass (grams and kilograms)
- make graphs to identify patterns and trends

Section 3: Activity 1

Note: Although there is a choice of doing either Part A or Part B, students are encouraged to do Part A. Only in circumstances where it is not possible to complete Part A are students to do Part B.

Part A

Comments:

Part A involves using actual equipment to measure mass and weight. Assist students to obtain a spring scale, balance scale, and a set of standard masses calibrated in grams to enable students to complete this part of the activity.

Observations

Object Measured	Mass of Object	Weight of Object
apple	*Answers will vary. In each case the mass of the object is to be in grams or kilograms and the weight in newtons. The number of newtons will be about $\frac{1}{100}$ of the number of grams.* *Check to see that the student measured the mass and weight of three objects of their own choice in addition to the three objects stated.*	
eraser		
book		

Questions to Answer

1. What is used to measure the mass of each object?

A balance scale should be used.

2. What is used to measure the weight of each object?

   A spring scale should be used.

3. Write the name and symbol for a unit of mass.

   gram (g) or kilogram (kg)

4. Write the name and symbol for a unit of weight.

   newton (N)

5. What does *mass* mean?

   Mass has to do with the amount of matter in an object. (It is measured in grams or kilograms.)

6. What does *weight* mean?

   Weight has to do with the force of gravity on an object. (It is measured in newtons.)

Part B

Comments:

Some sample results of masses and weights of objects are given in the observation chart for Part B. Using these as guide lines, students are to complete the rest of the chart. Check to see that the observation chart is properly completed and that the correct units of measurement were used.

7. Complete the observation chart. When recording your answers, be careful to use the correct units (grams or newtons) along with the numbers.

Observations

Object Measured	Mass of Object	Weight of Object
banana	175 g	*1.75 N*
container of yogourt	*500 g*	5 N
bag of sugar	2 kg	*20 N*
box of salt	*1 kg (or 1000 g)*	10 N
carton of crackers	250 g	*2.5 N*
box of cereal	*625 g*	6.25 N

8. Answer questions 1 to 6 in Part A.

   Check to see that questions 1 to 6 of Part A have been answered.

Section 3: Activity 2

Note: Students are to do either Part A or Part B.

Part A: Interplanetary Exploration of Weight and Mass

Read the imaginary story, An Interplanetary Holiday, on pages 158 and 159 of *Science Directions 7* . This story is about how Shelly, a Grade 7 student, came to understand the difference between weight and mass. After reading her story and examining the record of the data she collected, answer the following questions.

1. Why do you think the weight of the silver block was different on each of the planets?

   The gravitational force is different on each of the planets.

2. Why didn't the mass, as measured on the balance scale, change from planet to planet?

   The amount of matter in the silver block does not change.

3. a. On which planet was the weight of the silver the greatest?

   The weight of the silver was the greatest on Earth.

   b. On which planet was the weight of the silver the least?

   The weight of the silver was the least on Mercury.

4. a. Which planet has the greatest force of gravity? How do you know?

   Earth has the greatest force of gravity of the four planets listed. This is shown by the silver weighing more on Earth than on any of the other three planets.

   b. Which planet has the smallest force of gravity? How do you know?

   Mercury has the smallest force of gravity. This is shown by the silver weighing less on Mercury than on any of the other three planets.

5. If you could travel to any of these planets to perform a high jump, which would you choose and why?

   On Mercury you could jump the highest because of the smaller force of gravity.

6. What would happen if gravity weren't holding things down? Write down all the benefits of gravity you can think of.

   Answers will vary. If there were no gravity, people would not likely be on the Earth. In fact, there probably would not be an Earth. All materials would be moving freely in space. Gravity is useful in keeping things in place and in providing friction so that things can be moved.

Part B: Interplanetary Investigation – Challenging Your Thinking About Weight and Mass

Planetary Data

Planet	Mass of Planet ($t \times 10^{20}$)	Distance from the Sun (Gm)	Length of Day (h)
Mercury	3	58	1400
Venus	48	108	5800
Earth	60	150	24
Mars	6	228	24

Questions for Investigation

7. Now it is your turn. Write your own hypothesis for what you think will most likely affect the **mass** of an object when measured on different planets.

   Your Hypothesis (mass of boulder):

   Answers will vary. Students might indicate any of the variables from the "Planetary Data" chart. (e.g., They might say mass of planet, distance from the sun, or length of day will most likely affect the mass on an object.)

8. Scientists generally have good reasons for their hypotheses. Do you have any reasons for yours? It may be difficult for you to give good reasons, but try anyway. Remember, scientists are always prepared to change their hypotheses, so you shouldn't worry if yours requires changing.

   Reasons for Hypothesis:

   Answers will vary. Look for evidence of critical thought.

9. Since a trip to the planets is fairly expensive, you should also measure the **weight** of the boulder on each planet. Of course, you measure the weight using a spring scale and the units are newtons(N).

   Which variable do you think would affect the weight of an object when measured on different planets? Would any of these make a difference?

   - mass of each planet
   - distance of each planet from the Sun
   - length of a day on each planet

   Your Hypothesis (weight of boulder):

   Answers will vary. Students might indicate any of the variables from the "Planetary Data" chart.

   Reason for Hypothesis:

   Answers will vary. Look for evidence of critical thought.

Observations

Now you are ready to make some measurements and check your hypothesis. You will have to use your imagination since a space ship is too big to work within your classroom or your home.

Here is a close approximation of the measurements you would have collected if a trip to the planets was actually possible.

Weight and Mass of a Boulder on Different Planets

Planet	Mass of Boulder in Grams (g)	Mass of Boulder in Kilograms (kg)	Weight of Boulder in Newtons (N)
Mercury	10 000	10	36
Venus	10 000	10	86
Earth	10 000	10	100
Mars	10 000	10	40

Use the information gained so far in Part B to answer the following questions.

10. Did the mass of the boulder change when it was measured on different planets?

    No, the mass did not change.

11. Which of the following hypotheses fit the findings of your research? Circle the one that fits best.

    a. The mass of an object is larger if measured on a planet with a larger mass.

    b. The mass of an object is smaller if measured on a planet with a larger mass.

    c. The mass of an object is not affected by the mass of the planet it is on.

12. Which of the following hypotheses fit the findings of your research? Circle the one that fits best.

    a. The mass of an object is larger if measured on a planet farther from the Sun.

    b. The mass of an object is smaller if measured on a planet farther from the Sun.

    c. The mass of an object is not affected by the distance of the planet from the Sun.

13. Which of the following hypotheses fit the findings of your research? Circle the one that fits best.

    a. The mass of an object is larger if measured on a planet with a longer day.

    b. The mass of an object is smaller if measured on a planet with a longer day.

    c. The mass of an object is not affected by the length of a planet's day.

14. Did the weight of the boulder change when it was measured on different planets?

    Yes, the weight varied from 36 N to 100 N.

15. Which of the following hypotheses fit the findings of your research? Circle the one that fits best.

    a. An object weighs more on a planet with a larger mass.

    b. An object weighs less on a planet with a larger mass.

    c. The weight of an object is not affected by the mass of the planet it is on.

    d. There is no clear pattern to the observations.

16. Which of the following hypotheses fit the findings of your research? Circle the one that fits best.

    a. An object weighs more on a planet farther from the Sun.

    b. An objects weighs less on a planet farther from the Sun.

    c. The weight of an object is not affected by the distance of the planet from the Sun.

    d. There is no clear pattern to the observations.

17. Which of the following hypotheses fit the findings of your research? Circle the one that fits best.

    a. An object weighs more on a planet with a longer day.

    b. An object weighs less on a planet with a longer day.

    c. The weight of an object is not affected by the length of a planet's day.

    d. There is no clear pattern to the observations.

18. You may remember that the first part of Sir Isaac Newton's laws of gravitation stated that:

    An object that has a large mass has a greater force of gravity than an object that has less mass.

    a. Do the observations from your imaginary trip to the planets agree with this statement?

       yes

    b. Give a reason for your answer.

       The planets with the greatest mass exerted the greatest amount of force.

Section 3: Activity 3

Read the information on page 160 of *Science Directions 7* . The data from the diagram can be shown in chart form as follows.

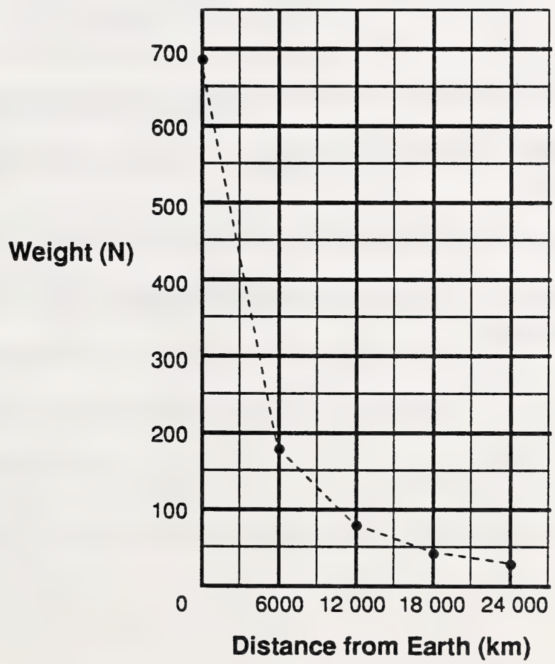
Distance from the Earth Versus Mass and Weight

Distance from Earth (km)	Mass of Astronaut (kg)	Weight of Astronaut (N)
0	68	680
6 000	68	170
12 000	68	76
18 000	68	43
24 000	68	27

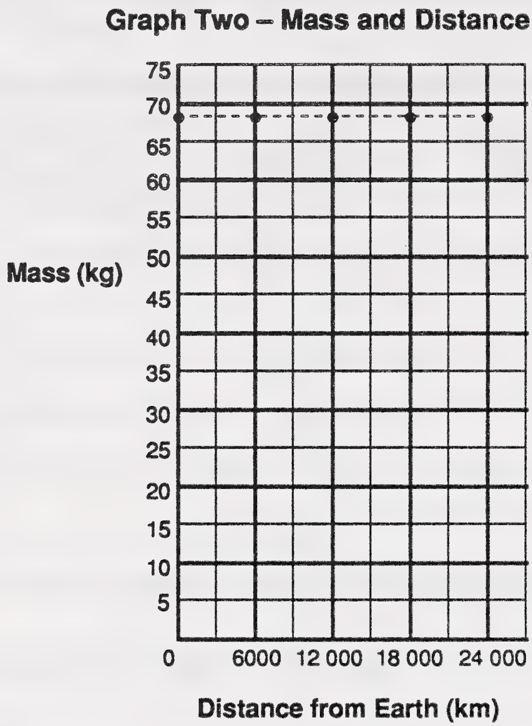
1. The data can also be shown in graph form.

   a. Make a graph to show how an astronaut's weight changes as the distance from Earth increases.

Graph One – Weight and Distance



b. Make a second graph to show the relationship between distance from Earth and an astronaut's mass.



c. What is the relationship between an astronaut's weight and the distance from Earth?

Graph One shows that the weight of an astronaut decreases as the distance from the Earth increases.

d. What is the relationship between distance from Earth and an astronaut's mass?

Graph Two shows that an astronaut's mass remains constant, no matter what the distance is from the Earth.

2. Think about an astronaut on a trip from the Earth to the Moon. As the astronaut moves away from the Earth, the force of gravity between the astronaut and the Earth becomes smaller. But gravity acts between all objects in the universe. As the astronaut moves toward the Moon, the force of gravity between the astronaut and the Moon becomes greater.

   There is a special point, about nine-tenths of the way to the Moon, where the pull of the Earth's gravity is balanced by the pull of the Moon's gravity. At that point, the astronaut experiences a force of gravity of 0 N. Why do you think this special point is so much closer to the Moon than it is to the Earth?

   The Earth is much larger and exerts a stronger pull of gravity than does the Moon.

Section 3: Follow-up Activities

Extra Help

For each of the following, circle the T if the statement is true. If the statement is false, circle the F, and rewrite the statement on the line beneath to make the statement true.

T F 1. Gravity acts between some objects.

Gravity acts between all objects.

T F 2. Mass and weight are both measured in kilograms.

Mass is measured in kilograms; weight is measured in N.

T F 3. Mass remains the same wherever you are.

T F 4. Forces are measured in newtons.

T F 5. Weight is a measure of the mass of an object.

Weight is a measure of the force of gravity on an object.

T F 6. A balance scale is used to measure mass.

T F 7. A scale calibrated in grams is used to measure weight.

A scale calibrated in grams is used to measure mass.

T F 8. Weight increases as you move away from the Earth's surface.

Weight decreases as you move away from the Earth's surface.

T (F) 9. Mass is a force.

Weight is a force.

For questions 10 to 15, fill in the blank with a word or phrase that correctly completes the sentence. Use words from the following list. Use each word only once. You will not use all of these words.

Word List

decrease	increase
force	less
grams	mass
graph	newtons
gravity	scale
greater	weight

10. *Weight* changes as the force of gravity changes.

11. If the distance between two objects is increased, the force of gravity between the objects will *decrease*.

12. The weight of an object will be more if it is measured on a planet that has *greater* mass.

13. A pan balance can be used to measure *mass*.

14. Mass is reported in units called *grams (or kilograms)*.

15. A *graph* can be used to show a pattern between two sets of data.

Enrichment

Note: Students may do either Part A or Part B, or they may do both Part A and Part B.

Comments:

Part A involves mathematical calculations. Some skill in working with ratios and proportions is required. Part B involves designing an experiment. Students are not required to do the experiment, just to develop a method.

Part A

Comments:

Students are to use the information given under Part A in the Student Module Booklet along with information from the chart "Distance from the Earth Versus Mass and Weight" in Activity 3 or the illustration on page 160 of the textbook, *Science Directions 7*, to answer the following questions.

1. A car has a mass of one tonne (1 t). This is equal to 1000 kg.

   a. What is the mass of the car in grams?

   The mass of the car is 1 000 000 grams.

   b. What is the weight of the car in newtons?

   The weight of the car is about 10 000 newtons.

   c. How much would the car weigh 6000 km above the Earth's surface?

   The car would weigh about 2500 newtons 6000 km above the Earth's surface.

   From the chart in Activity 3, the weight of an astronaut at the surface of the Earth is 680 N, but at 6000 km from Earth it is 170 N. The weight of the car at the Earth's surface is 10 000 N. When you solve for x in the following proportion you find its value to be 2500 N.

   $$\frac{680\text{ N}}{170\text{ N}} = \frac{10\,000\text{ N}}{x\text{ N}}$$

   d. How much would the car weigh 18 000 km above the Earth's surface?

   The car would weigh about 630 newtons 18 000 km above the Earth's surface.

   This time the following proportion would apply.

   $$\frac{680\text{ N}}{43\text{ N}} = \frac{10\,000\text{ N}}{x\text{ N}}$$

   e. What would the weight of the car be on the Moon?

   The weight of the car would be about 1700 newtons on the Moon.

   $\frac{1}{6}$ *of 10 000 N is about 1700 N when rounded off.*

   f. What would the mass of the car be on the Moon?

   The mass of the car would be about 1000 kg on the Moon.

2. Using a bathroom scale, measure your mass in kilograms.

   a. What is your mass in kilograms?

      Answers will vary.

   b. What is your mass in grams?

      This answer should be 1000 times the answer for a. (above).

   c. What is your weight in newtons?

      This answer should be about 10 times the answer for a. (above).

   d. How much would you weigh 6000 km above the Earth's surface (12 000 km from the centre of the Earth)?

      This answer should be about one-quarter the answer in c. (above).

      The calculation here would be similar to that used in question 1. c. except the student's weight would be used in place of the car's weight. For example, a student having a 50 kg mass on the surface of Earth would have a weight of 500 N on the Earth's surface, but it would be 125 N 6000 km above the Earth's surface.

   e. How much would you weigh 18 000 km above the Earth's surface (24 000 km from the centre of the Earth)?

      This answer should be about one-quarter of the answer for d.

      The calculation here would be similar to that used in question 1. d. except the student's weight would be used instead of the car's weight.

   f. What would your weight be on the Moon?

      The student's weight will be about $\frac{1}{6}$ *of what the weight is on Earth.*

   g. What would your mass be on the Moon?

      The student's mass will be the same as it is on Earth.

Part B

Develop a method for an experiment that would test the idea that all objects with mass attract each other. Since you won't have to actually do the experiment, you can choose any existing equipment. The important thing is that if you did do it, the experiment will actually work. State your answers under questions 3 and 4 which follow.

3. Briefly describe how to do the experiment.

   Answers will vary. Students should indicate some way of measuring the force between two objects. The means of measuring does not need to be worked out in detail, but the intent should be clear that a procedure is to be established where a force measurement can be made. For example, some students may develop a method whereby they use force metres or spring scales calibrated in newtons to measure forces of attraction between objects. Other students may feel that the gravitational pull between objects on Earth is too small to be measured reliably, so they will choose a method involving space travel and describing a way of measuring the force of gravity between pairs of objects in the universe. Still others may choose to describe a method involving measuring the effect of the Moon upon objects on Earth, such as describing a method for measuring the Moon's effect upon producing ocean's tides.

4. Describe what observations from your experiment would support the idea that all objects with mass attract each other.

   Answers will vary. The key idea is that if there is such a force, then it should be measurable between any two objects studied. (The more massive the objects, the greater the forces should be.)

Section 3 Assignment

(20 Total Possible Marks)

1. Why should the mass of an object, as measured on a balance scale, stay the same if measured on Earth and on the Moon? (3)

   The mass is the amount of matter in an object. This does not change when the position of the object changes.

2. Why should the weight of an object, as measured with a spring scale, change if measured on Earth and on the Moon? (3)

   The force of gravity is different in the two locations.

3. What is the difference between a newton and a gram? (4)

   A newton is a unit of force. A gram is a unit of mass.

4. How can you calculate the weight of an object on Earth if you know its mass? (3)

   For every 100 g, the object will weigh about 1 N. If you divide the number of grams by 100, this will give the approximate weight in newtons.

5. The *Canadarm* is a robotic arm that is able to lift a satellite out of the cargo bay of a space shuttle. On Earth, the Canadarm is not even able to lift itself. Explain why the Canadarm is effective in space but not on Earth. (4)

   The movement of the arm must overcome the effects of gravity on Earth. In space there is little or no gravitational force.

6. There is a special point, about nine-tenths of the way to the Moon, where the pull of the Earth's gravity is just balanced by the pull of the Moon's gravity. At that point, an astronaut experiences a force of gravity of zero. Why do you think this special point is so much closer to the Moon than it is to the Earth? (3)

   The Earth is larger and has a stronger gravitational force.

Section 4: What Makes Things Move or Stay in Place?

By the end of this section students should be able to

- predict the pathways of moving objects
- identify evidence and effects of friction
- describe methods of increasing or decreasing friction
- identify action-reaction pairs

Section 4: Activity 1

Now turn to pages 146 and 147 of *Science Directions 7* and review the information under Balanced and Unbalanced Forces. Answer the following questions.

1. What is the upward force acting on the book in the illustration?

   The muscles in the hand provide the upward force.

2. What is the downward force acting on the book?

   Gravity is the downward force.

3. Define *balanced forces*.

   Two forces of equal strength acting on an object in opposite directions are balanced forces.

4. What force is causing the toboggan to move forward?

   The man's pulling force is causing the toboggan to move forward.

5. What force is tending to hold the toboggan back?

   Friction tends to hold the toboggan back.

6. Define *unbalanced forces.*

   When a force acting on an object is greater than another force acting on the object in the opposite direction, the two forces are said to be unbalanced.

Section 4: Activity 2

Questions to Answer

1. a. Did the index card move?

      Yes, the index card moved.

   b. If it did, in which direction did it move?

      It moved in the direction in which it was pushed (by flicking one's finger).

2. a. Did the penny move?

      No, if done as directed, the penny will not move.

   b. If it did, in which direction did it move?

      It did not move. If there is a movement, it should be slight and it should be in the direction the card was moved.

3. Did you apply a force to the index card?

   yes

4. Did you apply a force to the penny?

   no

5. Explain why this trick works, using Newton's ideas about objects at rest.

   The inertia (the resistance to change) of the penny kept it from moving. An object at rest tends to remain at rest, unless a force is applied to it.

Questions to Answer (continued)

6. a. Did the index card move?

   Yes, the index card moved.

   b. If it did, in which direction did it move?

   It moved in the direction in which it was pushed.

7. a. Did the penny move?

   Yes, the penny moved.

   b. If it did, in which direction did it move?

   It moved downward into the glass.

8. Did you apply force to the index card?

   yes

9. Did you apply force to the penny?

   No, the force of gravity caused the penny to be moved downward into the glass.

Section 4: Activity 3

1. Look at illustration C. Tyler has to deliver the large pile of newspapers. As he starts out, the papers fall off the back of the wagon.

   a. Explain why the papers fell by describing the motions and forces that are involved.

   The papers fell off the back of the wagon because their inertia at rest kept them in their original place as the wagon moved forward.

   b. What would you advise Tyler to do the next time he starts out?

   Tyler should start the wagon moving very slowly and gently, and/or he could hold onto the papers as the wagon starts to move.

2. Look at illustration D on page 182 of the textbook. Tyler puts the papers back on the wagon. He starts out again. The wagon wheel hits a rock and the papers fall off the front of the wagon.

   a. Explain why the papers fell this time by describing the motions and forces that are involved.

   The papers fell off the front of the wagon because their inertia in motion kept them moving when the wagon stopped suddenly.

b. What advice would you give Tyler now?

Tyler should avoid situations where he must stop suddenly, and he should bring the wagon slowly and gently to a halt.

3. Look at the illustration for question 5 on page 182 of the textbook. Use what you know about the inertia of moving objects to explain why it is always a good idea to do up your seat belt when in a car.

   If a car were to stop suddenly and you did not have your seat belt on, the inertia of your body in motion would make you continue to move forward, perhaps throwing you out of your seat and into the windshield.

4. Place an index card on a table and put the penny on it; then pull the card forward suddenly. (This is a repeat of the card and penny trick.) The penny stays still or appears to move backward compared to the card. Which of the two ideas about inertia explains what happens?

   Objects at rest do not move unless a force acts upon them.

5. Place the card on a table and put the penny on it again. This time, pull the card forward slowly, gradually increasing the speed, so that the penny stays on the card. Suddenly stop the card. The penny keeps moving forward. Which of the two ideas about inertia explains what happens?

   Objects already moving continue to move at the same speed and in the same direction, unless an unbalanced force acts on them.

Section 4: Activity 4

Observations

Surface	Force Needed to Pull One Brick (N)	Force Needed to Pull Two Bricks (N)
wood	*Answers will vary.*	
linoleum		
linoleum and oil		

Questions to Answer

1. Which surface resisted the motion of one brick with the greatest force?

   Depending on the surface finish, it may be the wood or the linoleum.

2. Which surface resisted the motion of one brick with the least force?

   The oiled linoleum surface would have the least force.

3. a. Which surface provided the greatest force of friction?

      Answers may vary. It could be either the wood or the linoleum.

   b. How do you know?

      The force to move the bricks was greatest for this surface.

4. What was the effect of doubling the number of bricks?

   The effect was an increase of the force required to move the bricks.

5. What was the effect of putting oil on the linoleum?

   The force required to move the bricks was decreased.

6. Predict the effect of pulling the brick over the wood if the wood was covered with sandpaper.

   Answers will vary, but most likely the force required should increase.

7. What is one way to reduce the force of friction between two surfaces?

   Smooth the surface; or lubricate the surface.

8. What is one way to increase the force of friction between two surfaces?

   You could roughen the surface.

9. Cars with front-wheel drive usually are able to move over snow and ice better than cars with rear-wheel drive. Why?

   The extra weight of the engine over the drive wheels causes the car to get more traction.

Section 4: Activity 5

1. Hard surfaces that move against each other in a machine are often protected by a **bearing**. Look at the illustration of the bearings in a skateboard shown on page 166 of the textbook. How do bearings help reduce the effects of friction?

   The surfaces roll over each other instead of sliding.

2. **Lubricants** such as oil are used to reduce friction. Identify two spots on a bicycle on which you could use oil to reduce friction.

   a. Circle the spots on this picture of the bicycle.

   Answers will vary. Students may circle the wheel hubs, the points of contact along the chain, or the crankshaft (pedal) axle.

   b. Why did you choose these two spots?

   Answers will vary. Points chosen should be places where one part makes contact with another part that is moving.

3. Keep your hands together tightly while you rub them quickly back and forth several times. You should feel another effect of friction – heat. Describe two other examples in which friction causes heat.

   Answers will vary.
   Example answers:

   - *The brakes on a car or on a bicycle become warm or hot after a long, downhill ride.*

   - *An early method of starting a fire was to rub a piece of wood rapidly over and over again against another piece of wood.*

4. Look at the bottom of one of your shoes. Describe evidence of friction.

   Parts of the sole will be worn off.

5. Look at a tire on a bicycle or on a car. Describe evidence of friction.

   The bicycle or car tire will show signs of wear.

Section 4: Activity 6

Note: Students are to do either Part A or Part B.

Part A

Follow the instructions and answer the questions.

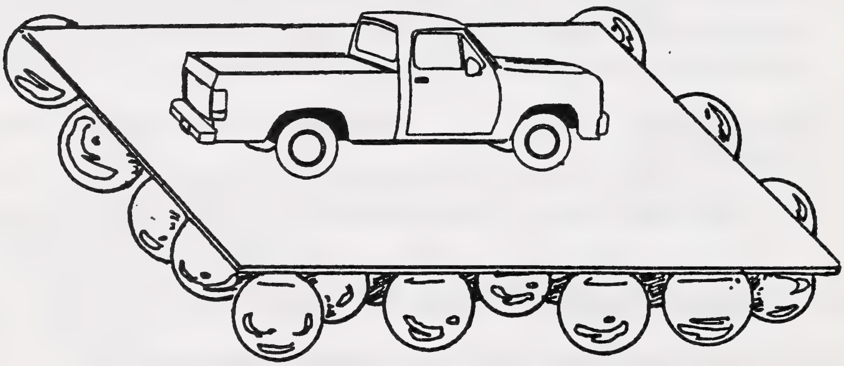
- Put the marbles close together on a smooth surface, and carefully lay the cardboard on top of them.

1. **Predict** what will happen if you wind up the car/truck and place it on the cardboard.

   Prediction:

   The car/truck will move across the cardboard.

- Wind up (or turn on) the toy car/truck; then set it carefully on the cardboard.



2. Record your observations here.

   When the motor is turned on, the cardboard is pushed back by the car/truck at the same time as the car/truck starts to move forward.

3. In what direction do the wheels push on the cardboard?

   They push back on the cardboard.

4. How does a car/truck on a road move forward? Explain in terms of action and reaction?

   A car/truck pushes against the road. The action of the tire against the road causes the reaction of the car/truck moving forward.

Part B

Questions to Answer

5. What action takes place first?

   The action which takes place first is the air rushing out of the balloon.

6. What is the reaction that takes place as a result?

   The reaction is the movement of the balloon.

7. In which direction is the first action, and in what direction is the reaction?

   first action:

   The air moves out of the balloon to the left.

   reaction:

   The balloon moves to the right.

8. Explain how this demonstration serves as a model of action and reaction forces in a rocket.

   The rocket or the balloon can only move forward if there is some material that is moved in the opposite direction.

Section 4: Follow-up Activities

Extra Help

Comments:

In place of a table tennis ball and golf ball, other objects of similar size but different masses can be used. For example, a glass marble and steel ball bearing, or a regular tennis ball and a baseball will work well.

Follow the instructions and answer the questions.

1. Predict what will happen when you place a golf ball on a smooth floor and roll a table tennis ball into it.

   Prediction:

   Answers will vary.

2. Try it. Then record your observations.

   Observations:

   The table tennis ball stops and bounces off in the other direction. The golf ball is only moved slowly in the other direction.

3. Predict what will happen when you roll the golf ball into the table tennis ball.

   Prediction:

   Answers will vary.

4. Try it. Then record your observations.

   Observations:

   The table tennis ball starts to move rapidly in the other direction (more rapidly than the golf ball was moving when it hit it). The golf ball slows down but does not stop.

5. Explain your observations in questions 2 and 4 in terms of what you have learned about mass and inertia.

   Objects that have more mass have more inertia. Objects tend to keep moving or stay where they are unless acted on by a force.

6. Look at the illustration of the truck and car shown on page 183 of the textbook. The truck and car are travelling at the same speed. They are both going to brake at the line shown. Which do you think will require more braking force to bring it to a stop? Why?

   The truck will require more braking force as it has more mass and greater inertia.

Enrichment

Students may do either Part A or Part B, or, they may do both Part A and Part B.

Part A: Effects of Friction

This thought experiment is based on the information given on pages 168 and 169 of *Science Directions 7*. Read the textbook information carefully; then answer the following questions.

1. Imagine that it is a beautiful, warm, and calm day. You set out on a bicycle ride.

   a. What do you feel against your skin, hair, and clothes as you pedal along?

      As you pedal along you create a slight breeze against your skin, hair, and clothes. Your skin begins to feel cool as a result.

   b. How does what you feel change as you move faster?

      You feel cooler as the air rushes past.

2. Imagine you are at the beach with a friend. You decide to have a water race.

   a. How does running in the water compare with running on land?

      It is much more difficult. One cannot move nearly as fast.

   b. What two surfaces are moving against each other as you move in water?

      The surface of your body moves against the water.

   c. Why is it harder to run in water than in air?

      It is harder to run in water because the frictional forces are greater; or, water is a more dense fluid than air.

3. Imagine that you are in a space shuttle as it returns to Earth. The engines are fired briefly to slow the craft down to 28 000 km/h. At this speed, the shuttle leaves orbit and starts to fall toward Earth. When the shuttle has fallen to a distance of 130 km above the Earth's surface, you can hear air beginning to brush the sides of the shuttle. Through the window you are able to see that the bottom part of the shuttle has started to glow with a red colour.

   a. Why is the shuttle starting to glow?

      The movement of the rapidly moving shuttle through the air causes the temperature on the outer surface of the shuttle to rise because of the friction between the air and the shuttle.

   b. The shuttle does not need its rockets to slow down its descent. What force will help it slow down as it travels toward the Earth's surface?

      Frictional force slows the shuttle.

Part B: Satellite Motion

Comments:

Part B is based on instructions given in the Student Module Booklet and on the information given on pages 186 and 187 of *Science Directions 7.*

> **Caution**
>
> Everyone should be at least 3 m from the model when it is being demonstrated.

- Answer the following questions.

1. What object in this model represents the satellite?

   The stopper represents the satellite.

2. What object in this model represents the Earth?

   The piece of tubing – or perhaps your hand represents the Earth.

3. a. What force was pulling the stopper closer to the tubing?

   The tension of the string pulled the stopper closer to the tubing.

   b. What force pulls a real satellite closer to the Earth?

   Gravitational force pulls a satellite closer to the Earth.

4. When more washers are added, do you need to increase or slow the speed of the stopper to keep it the same distance from the tubing?

   You need to increase the speed.

5. As a real satellite speeds up, what should happen to its orbit around the Earth?

   The radius of the object will increase. (It will orbit the Earth at a greater distance from the Earth.)

6. The Moon is a satellite of the Earth. It has been orbiting the Earth for millions and millions of years.

   a. What force keeps the Moon from moving away from the Earth?

   Gravitational force keeps the Moon from moving away from the Earth.

   b. What would happen if the Moon started to slow down in its orbit around the Earth?

   It would come closer to the Earth. (Its orbit would be closer to the Earth.)

7. The Earth is a satellite of the Sun. What keeps the Earth in an orbit around the Sun?

   The motion of the Earth and the gravitational force of the Sun keep the Earth in its orbit.

Section 4 Assignment

(35 Total Possible Marks)

1. Match the following statements with one or more of the examples given. On the following response page, write the statement number in the space next to the example or examples that it explains. (6)

   II a.

   I b.

   III c.

   IV d.

   I e.

   III f.

2. Examine the illustration on page 191 of *Science Directions 7*. Using what you know about the inertia of objects at rest, explain why Thread *A* breaks when you pull slowly on the ring and Thread *B* breaks if you give the ring a sudden jerk. (2)

   For a sudden movement, it takes more force to start the book moving downward than it does to hold the book up.

3. Describe an example of an object with balanced forces acting upon it. Identify the forces. (2)

   Answers will vary.
   Examples: For a desk sitting in a room, the forces are balanced. The downward force of gravity on the desk is balanced by the force upwards from the floor.

4. Describe an example of an object with unbalanced forces acting upon it. Identify the forces. (3)

   Answers will vary.
   Example: A ball shows unbalanced forces when hit by a bat. The ball will change direction when the bat hits it.

5. Describe one beneficial effect of friction. (3)

   Answers will vary.
   Example: Friction enables you to get a grip on things such as the grip between your feet and the ground. If you were not able to have such a grip (or traction), it would be difficult to move.

6. Describe one problem caused by friction. (3)

   Answers will vary.
   Examples:

   - *Friction causes materials to wear out.*
   - *Friction requires you to use energy that you otherwise would not have to use.*

7. Describe two ways to increase the force of friction. (4)

   Answers will vary.
   Examples:

   - *Frictional forces can be increased by making changes to surfaces that are rubbed together (e.g., roughening the surface).*

   - *Frictional forces can also be increased by increasing the force that pushes two surfaces together.*

8. Describe two ways to reduce the force of friction. (4)

   Answers will vary.
   Example: Frictional forces can often be reduced by smoothing the surfaces that are rubbed together, and by using a lubricant, such as oil.

9. Predict the changes in movement for each of the following objects. Then give reasons for your desciption. In your explanation, include the ideas of balanced forces, unbalanced forces, gravity, and friction.

   a. A ball is released at the top of an incline, as shown in the following diagram.

      i. Describe its motions. (2)

      The ball rolls downward on the incline and then along the flat surface. It continues to roll until it reaches the end of the flat surface or until stopped by friction.

      ii. Why should the ball move as you have described? (2)

      The motion of the ball is affected by the force of gravity. (1 mark)
      It is also affected by the force of the surface on the ball. (1 mark)

   b. A ball is released at the top of an incline, as shown in the following diagram.

      i. Describe its motions. (2)

      The ball rolls downward across the flat surface, up the other side, it stops, and then rolls back down. It continues to roll back and forth until friction brings it to a complete stop.

      ii. Why should the ball move as you have described? (2)

      Answers will vary.
      Example: The ball responds to the force of gravity and to the shape of the surface.

General Comment:

- A final grading for Module 3 can be determined at this point.

This booklet cannot be purchased separately; the Learning Facilitator's Manual is available only as a complete set.

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